**Claims**

What is claimed is:

1    1.    A method of controlling a semiconductor manufacturing tool using a feedback
2    control mechanism, comprising:

3    (a) receiving a plurality of data points relating to an output of the tool including a
4    current data point and at least one previous data point;

5    (b) determining whether the current data point is an outlier based on:

6    (b-1) comparing the current data point to a statistical representation of the
7    at least one previous data point; and

8    (b-2) whether the at least one previous data point is an outlier; and

9    (c) disregarding the current data point in calculating a feedback value of the
10   feedback control mechanism if the current data point is determined as an outlier.

1    2.    The method of claim 1, wherein (b) further comprises:

2    determining the current data point as an outlier only if the at least one previous
3    data point is not an outlier.

1    3.    The method of claim 1 or 2, further comprising:

2    (d) calculating the feedback value of the feedback control mechanism using the
3    current data point and the at least one previous data point if the current data point is
4    determined as not an outlier.

1    4.    The method of claim 1 or 2, further comprising:

2    (d) calculating a previous feedback value for the at least one previous data point
3    and then calculating the feedback value based on the previous feedback value and the

4  current data point if the at least one previous data point is an outlier and the current data

5  point is an outlier.

1  5.  The method of claim 1 or 2, wherein the statistical representation of (b-1) is a

2  weighted moving average of the at least one previous data point.

1  6.  The method of claim 1 or 2, wherein the statistical representation of (b-1) is an

2  exponentially-weighted moving average of the at least one previous data point.

1  7.  The method of claim 1 or 2, wherein the statistical representation of (b-1) is

2  expressed as:

3  $$S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$$

4  where,

5  $\beta$  is a coefficient;

6  $F_k$  is the difference between the current data point and predicted values for wafer $k$;

7  and

8  $\Delta_k$  is a feedback value for time $k$.

1  8.  The method of claim 7, wherein the value of $\Delta_k$ is calculated as:

2
$$if\ |F_k - \Delta_k| \le K_n s_k$$
$$\Delta_{k+1} = \lambda_k F_k + (1 - \lambda_k)\Delta_k$$
$$else$$
$$\Delta_{k+1} = \Delta_k$$

3  where, $\lambda_k$ is a coefficient;

4  $K_n$ is an outlier coefficient; and

5  $s_k = \sqrt{S_k}$ .

1  9.  The method of claim 7, further comprising:

2  updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$ when the current data point is

3  determined as not an outlier.

1  10.  The method of claim 7, further comprising:

2  updating $S_k$ as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

1    11.    The method of claim 6, further comprising:

2         updating $S_k$ as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1 - \beta)S_{k-1}$ ; and then

3         updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$, when the current data point is

4   determined as not an outlier and the previous data was not determined as an outliner.

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1    12.    The method of claim 1 or 2, further comprising:

2         making a plurality of measurements on the output of the tool using at least one

3   metrology station; and

4         calculating the current data point based on the plurality of measurements.

1    13.    The method of claim 12, further comprising:

2         calculating an interval based on statistical information relating to the plurality of

3   measurements;

4         identifying a subset among the plurality of measurements that fall within the

5   interval; and

6         calculating the current data point from the subset of the plurality of the

7   measurements.

1    14.    The method of claim 13, wherein the statistical information relates to at least one

2   of a median and a standard deviation of the plurality of measurements.

1    15.    The method of claim 14, further comprising:

2         calculating the standard deviation based on one of a variance and a scaled

3   variance of the plurality of measurements.

1    16.    A system of controlling a semiconductor manufacturing tool using a feedback

2   control mechanism, comprising:

3         an estimator configured to receive a plurality of data points relating to an output

4   of the tool including a current data point and at least one previous data point,

5       wherein the estimator is further configured to determine whether the current data

6   point is an outlier based on comparing the current data point to a statistical representation

7   of the at least one previous data point, and whether the at least one previous data point is

8   an outlier, and

9       wherein the estimator is further configured to disregard the current data point in

10   calculating a feedback value of the feedback control mechanism if the current data point

11   is determined as an outlier.

1   17.     The system of claim 16, wherein the estimator is further configure to determine

2   the current data point as an outlier only if the at least one previous data point is an outlier.

1   18.     The system of claim 16, wherein the estimator is further configured to calculate

2   the feedback value of the feedback control mechanism using the current data point and

3   the at least one previous data point if the current data point is determined as not an

4   outlier.

1   19.     The system of claim 16, wherein the estimator is further configured to calculate a

2   previous feedback value for the at least one previous data point and then calculate the

3   feedback value based on the previous feedback value and the current data point if the at

4   least one previous data point is an outlier and the current data point is an outlier.

1   20.     The system of claim 16, wherein the statistical representation of is a weighted

2   moving average of the at least one previous data point.

1   21.     The system of claim 16, wherein the statistical representation of is an

2   exponentially-weighted moving average of the at least one previous data point.

1   22.     The system of claim 16, wherein the statistical representation of is expressed as:

2         $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$

3   where,

4   $\beta$     is a coefficient;

5    $F_k$    is the difference between the current data point and predicted values for wafer $k$;

6    and

7    $\Delta_k$    is a feedback value for time $k$.

1    23.    The system of claim 22, wherein the value of $\Delta_k$ is calculated as:

2

$$if \left| F_k - \Delta_k \right| \leq K_n s_k$$
$$\Delta_{k+1} = \lambda_k F_k + (1 - \lambda_k)\Delta_k$$
$$else$$
$$\Delta_{k+1} = \Delta_k$$

3    where, $\lambda_k$ is a coefficient;

4    $K_n$ is an outlier coefficient; and

5    $s_k = \sqrt{S_k}$ .

1    24.    The system of claim 22, wherein the estimator is further configured to update

2    $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$ when the current data point is determined as not an

3    outlier.

1    25.    The system of claim 22, wherein the estimator is further configured to update

2    $S_k$ as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

1    26.    The system of claim 22, wherein the estimator is further configured to update

2    $S_k$ as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1 - \beta)S_{k-1}$ ; and

3    $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$, when the current data point is determined as

4    not an outlier and the previous data was not determined as an outliner.

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1    27.    The system of claim 16, further comprising:

2    at least one metrology station configured to make a plurality of measurements on

3    the output of the tool, wherein the estimator is further configured to calculate the current

4    data point based on the plurality of measurements.

1    28.    The system of claim 27, the estimator is further configured to calculate an interval

2    based on statistical information relating to the plurality of measurements, configured to

3    identify a subset among the plurality of measurements that fall within the interval, and

4      configured to calculate the current data point from the subset of the plurality of the

5      measurements.

1      29.     The system of claim 28, wherein the statistical information relates to at least one

2      of a median and a standard deviation of the plurality of measurements.

1      30.     The system of claim 29, the estimator is further configured to calculate the

2      standard deviation based on one of a variance and a scaled variance of the plurality of

3      measurements.

1      31.     A system of controlling a semiconductor manufacturing tool using a feedback

2      control mechanism, comprising:

3              (a) means for receiving a plurality of data points relating to an output of the tool

4      including a current data point and at least one previous data point, where in the at least

5      one previous data point is received before the current data point;

6              (b) means for determining whether the current data point is an outlier based on:

7                      (b-1) comparing the current data point to a statistical representation of the

8      at least one previous data point; and

9                      (b-2) whether the at least one previous data point is an outlier; and

10             (c) means for disregarding the current data point in calculating a feedback value

11     of the feedback control mechanism if the current data point is determined as an outlier.

1      32.     The method of claim 31, further comprising:

2              means for determining the current data point as an outlier only if the at least one

3      previous data point is an outlier.

1      33.     The system of claim 31, further comprising:

2     (d) means for calculating the feedback value of the feedback control mechanism

3 using the current data point and the at least one previous data point if the current data

4 point is determined as not an outlier.

1    34.     The system of claim 31, further comprising:

2     (d) means for calculating a previous feedback value for the at least one previous

3 data point and then calculating the feedback value based on the previous feedback value

4 and the current data point if the at least one previous data point is an outlier and the

5 current data point is an outlier.

1    35.     The system of claim 31, wherein the statistical representation of is a weighted

2 moving average of the at least one previous data point.

1    36.     The system of claim 31, wherein the statistical representation of is an

2 exponentially-weighted moving average of the at least one previous data point.

1    37.     The system of claim 31, wherein the statistical representation of is expressed as:

2     $$S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$$

3 where,

4     $\beta$     is a coefficient;

5     $F_k$     is the difference between the current data point and predicted values for wafer $k$;

6 and

7     $\Delta_k$     is a feedback value for time $k$.

1    38.     The system of claim 37, wherein the value of $\Delta_k$ is calculated as:

2
$$if |F_k - \Delta_k| \le K_n s_k$$
$$\Delta_{k+1} = \lambda_k F_k + (1 - \lambda_k)\Delta_k$$
$$else$$
$$\Delta_{k+1} = \Delta_k$$

3     where, $\lambda_k$ is a coefficient;

4     $K_n$ is an outlier coefficient; and

5     $s_k = \sqrt{S_k}$ .

1    39.    The system of claim 39, further comprising:

2        means for updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$ when the current data

3   point is determined as not an outlier.

1    40.    The system of claim 37, further comprising:

2        means for updating $S_k$ as $S_k = S_{k-1}$ when the current data point is determined as

3   an outlier.

1    41.    The system of claim 37, further comprising:

2        means for updating $S_k$ as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1 - \beta)S_{k-1}$ ; and then

3        means for updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$, when the current data

4   point is determined as not an outlier and the previous data was not determined as an

5   outliner.

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1    42.    The system of claim 31, further comprising:

2        means for making a plurality of measurements on the output of the tool using at

3   least one metrology station; and

4        means for calculating the current data point based on the plurality of

5   measurements.

1    43.    The system of claim 42, further comprising:

2        means for calculating an interval based on statistical information relating to the

3   plurality of measurements;

4        means for identifying a subset among the plurality of measurements that fall

5   within the interval; and

6        means for calculating the current data point from the subset of the plurality of the

7   measurements.

1    44.    The system of claim 43, wherein the statistical information relates to at least one

2   of a median and a standard deviation of the plurality of measurements.

1    45.    The system of claim 44, further comprising:

2          means for calculating the standard deviation based on one of a variance and a

3    scaled variance of the plurality of measurements.

1    46.    A computer readable medium for storing instructions being executed by one or

2    more computers, the instructions directing the one or more computers for controlling a

3    semiconductor manufacturing tool using a feedback control mechanism, the instructions

4    comprising implementation of the steps of:

5          (a) receiving a plurality of data points relating to an output of the tool including a

6    current data point and at least one previous data point;

7          (b) determining whether the current data point is an outlier based on:

8                (b-1) comparing the current data point to a statistical representation of the

9    at least one previous data point; and

10                (b-2) whether the at least one previous data point is an outlier; and

11          (c) disregarding the current data point in calculating a feedback value of the

12    feedback control mechanism if the current data point is determined as an outlier.

1    47.    The method of claim 46, further comprising:

2          determining the current data point as an outlier only if the at least one previous

3    data point is an outlier.

1    48.    The medium of claim 46, further comprising:

2          (d) calculating the feedback value of the feedback control mechanism using the

3    current data point and the at least one previous data point if the current data point is

4    determined as not an outlier.

1    49.    The medium of claim 46, further comprising:

2      (d) calculating a previous feedback value for the at least one previous data point

3      and then calculating the feedback value based on the previous feedback value and the

4      current data point if the at least one previous data point is an outlier and the current data

5      point is an outlier.

1      50.     The medium of claim 46, wherein the statistical representation of (b-1) is a

2      weighted moving average of the at least one previous data point.

1      51.     The medium of claim 46, wherein the statistical representation of (b-1) is an

2      exponentially-weighted moving average of the at least one previous data point.

1      52.     The medium of claim 46, wherein the statistical representation of (b-1) is

2      expressed as:

3      $$S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$$

4      where,

5      $\beta$      is a coefficient;

6      $F_k$      is the difference between the current data point and predicted values for wafer $k$;

7      and

8      $\Delta_k$      is a feedback value for time $k$.

1      53.     The medium of claim 52, wherein the value of $\Delta_k$ is calculated as:

2
$$if \left| F_k - \Delta_k \right| \leq K_n s_k$$
$$\Delta_{k+1} = \lambda_k F_k + (1 - \lambda_k)\Delta_k$$
$$else$$
$$\Delta_{k+1} = \Delta_k$$

3      where, $\lambda_k$ is a coefficient;

4      $K_n$ is an outlier coefficient; and

5      $s_k = \sqrt{S_k}$ .

1      54.     The medium of claim 52, further comprising:

2      updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$ when the current data point is

3      determined as not an outlier.

1   55.   The medium of claim 52, further comprising:

2   updating $S_k$ as $S_k = S_{k-1}$ when the current data point is determined as an outlier.

1   56.   The medium of claim 52, further comprising:

2   updating $S_k$ as $S_{k-1} = \beta(F_{k-1} - \Delta_{k-1})^2 + (1 - \beta)S_{k-1}$ ; and then

3   updating $S_k$ as $S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$, when the current data point is

4   determined as not an outlier and the previous data was not determined as an outliner.

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1   57.   The medium of claim 46, further comprising:

2   making a plurality of measurements on the output of the tool using at least one

3   metrology station; and

4   calculating the current data point based on the plurality of measurements.

1   58.   The medium of claim 57, further comprising:

2   calculating an interval based on statistical information relating to the plurality of

3   measurements;

4   identifying a subset among the plurality of measurements that fall within the

5   interval; and

6   calculating the current data point from the subset of the plurality of the

7   measurements.

1   59.   The medium of claim 58, wherein the statistical information relates to at least one

2   of a median and a standard deviation of the plurality of measurements.

1   60.   The medium of claim 59, further comprising:

2   calculating the standard deviation based on one of a variance and a scaled

3   variance of the plurality of measurements.

1   61.   A system of manufacturing semiconductor devices using a feedback control

2   mechanism, comprising:

3          at least one processing tool configured to perform at least one semiconductor

4   fabrication step on at least one wafer;

5          at least one metrology station coupled to the at least one processing tool and

6   configured to make measurements on the at least one wafer;

7          an estimator configured to receive a plurality of data points relating to an output

8   of the at least one tool including a current data point and at least one previous data point

9   calculated base on the measurements made by the at least one metrology station,

10          wherein the estimator is further configured to determine whether the current data

11   point is an outlier based on comparing the current data point to a statistical representation

12   of the at least one previous data point, and whether the at least one previous data point is

13   an outlier, and

14          wherein the estimator is further configured to disregard the current data point in

15   calculating a feedback value of the feedback control mechanism if the current data point

16   is determined as an outlier.

1   62.     The system of claim 61, wherein the estimator is further configure to determine

2   the current data point as an outlier only if the at least one previous data point is an outlier.

1   63.     The system of claim 61, further comprising:

2          an optimizer coupled to the estimator to receive the feedback value and

3   configured to generate at least one control parameter for operating the at least one tool

4   based on the feedback value.

1   64.     The system of claim 61, wherein the at least one tool is an etcher.

1   65.     A method of controlling a semiconductor manufacturing tool using a feedback

2   control mechanism, comprising:

3          (a) receiving a plurality of data points relating to an output of the tool including a

4   current data point, a subsequent data point, and at least one previous data point;

5       (b) determining the current data point as an erroneous outlier:

6            (b-1) if a difference between the current data point and a predicted value,

7   which is calculated from a statistical representation of the at least one previous data point,

8   is outside of a threshold;

9            (b-2) if the at least one previous data point is not an outlier; and

10           (b-3) if the subsequent data point is not an outlier; and

11       (c) disregarding the current data point in calculating a feedback value of the

12   feedback control mechanism if the current data point is determined as an erroneous

13   outlier.

1   66.     The method of claim 65, wherein the statistical representation of (b-1) is an

2   exponentially-weighted moving average of the at least one previous data point.

1   67.     The method of claim 66, wherein the statistical representation of (b-1) is

2   expressed as:

3       $$S_k = \beta(F_k - \Delta_k)^2 + (1 - \beta)S_{k-1}$$

4   where,

5   $\beta$     is a coefficient;

6   $F_k$    is the difference between the current data point and predicted values for wafer $k$;

7   and

8   $\Delta_k$   is a feedback value for time $k$.

1   68.     The method of claim 67, wherein the threshold is calculated as:

2       $$|F_k - \Delta_k| \leq K_n s_k$$

3   where, $\lambda_k$ is a coefficient;

4   $K_n$ is an outlier coefficient; and

5   $s_k = \sqrt{S_k}$ .